

Effect of Varying Initial Energy on Multihop Routing Protocol in Wireless Sensor Network

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Abstract: Wireless sensor networks (WSNs) require protocols that make judicious use of the limited energy capacity of the sensor nodes. The sensor networks basically infrastructure less, self configured wireless networks used to monitor environmental conditions such as temperature, sounds etc. which and communicate with each other using radio signals. The sensor nodes have non chargeable batteries and they soon get drained out of energy after only few rounds of data transmission. Wireless Sensor Networks are composed of small sensor nodes in the network which may be hundreds or thousands in number. Much of the energy of the sensor nodes is spent in neighbor discovery and in inter cluster as well as intra cluster communication. Further if the base station is farther away from the clusters, the sensor nodes would have to expend more energy and would soon make the nodes drain out of their energy round by round thus leading to decreased lifetime of network. In this paper, impact of changing the initial energy parameter on the proposed multihop routing protocol as well as Assisted LEACH is analyzed so that its exact effect could be understood and interpreted in terms of performance parameters like throughput, average energy consumption so that reasons for packet drops, routing overheads could be understood in relation to routing of data packets over the network. The simulation results show that with the variation in initial energy there is sharp rise and decline of throughput of proposed protocol and the average energy consumption is less than Assisted LEACH protocol.

KEYWORDS: -Initial energy, Proposed multihop routing protocol, throughput.

I. INTRODUCTION

Energy consumption has always been an issue with the wireless sensor networks. Many techniques and methods have been proposed by many researchers over the years. The main features of WSNs are scalability with respect to the number of nodes in the network, self-organization, self-healing, energy efficiency, a sufficient degree of connectivity among nodes, low-complexity, low cost and size of nodes WSN can contain hundreds or thousands of sensing nodes deployed randomly. As the batteries of the sensor nodes are not chargeable, the need is to make the methods of data transmission so effective that the data should be able to be routed to the intended base station as quickly as possible thus minimizing delays and negating all kinds of the packet drops, routing overheads etc along with make the design of the routing protocol energy efficient. In wireless sensor network, sending of data is traditionally undertaken by multi-hop data forwarding schemes, so the primary goal of the route discovery is the discovery of a pair of intermediate nodes to be chosen to create or build

the numerous paths from the source to the sink nodes. There are several kinds of requirements used by the current multipath protocol to formulate informed routing decisions. Some of these parameters are; the number of path disjoint is one of the primary conditions, it allows every existing path disjoint to maximize its main path disjoint core conditions to give higher aggregated network resources. The random deployment of sensor nodes makes it almost impossible to find a bigger pair of node-disjoint path among sensor nodes and sink node.

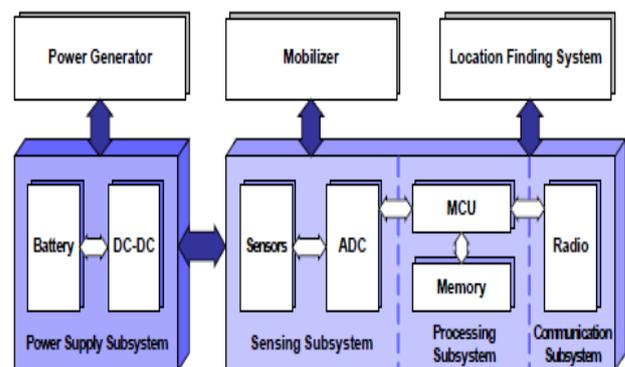


Fig 1 : Basic structure of sensor node in WSN[12]

The main task of a sensor node in a sensor field is to detect events, perform quick local data processing, and then transmit the data. For doing so, each sensor node has power supply system, sensing subsystem, processing subsystem and communication subsystem inbuilt in itself. The variety of possible applications of WSNs to the real world is practically unlimited, from environmental monitoring, health care, positioning and tracking, to logistic, localization, and so on but everywhere the longevity of such networks has been a source of concern as parameters such as QoS, maximum data transmission for any ideal network or a specific application cannot be compromised. Once data has been made available to the CHs, the next task is to route that data either using single hop manner or in multihop manner so that it could reach Base station. The results for homogeneous networks are better than heterogeneous networks but this fact is also true that the inclusion of certain heterogeneous nodes in the homogeneous environments can further improve the lifetime of the Wireless sensor network.

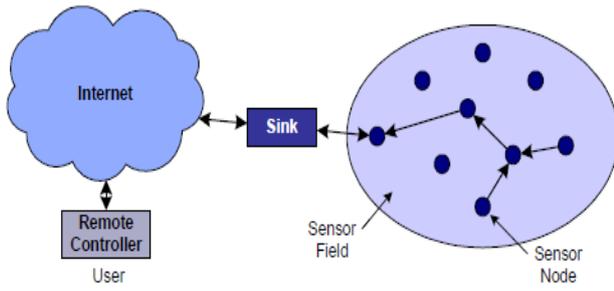


Fig 2: Structure of basic WSN [12]

The basic structure of wireless sensor network consists of various sensor nodes each having some initial energy , deployed or present randomly in a network with each node capable of communicating with all the other nodes in the network and all nodes can perform computations independently. The other main component for the wireless sensor network is the base station to which the data is to be sent by all the sensor nodes individually if flat routing is used and via cluster heads if hierarchical routing is used. But the essential characteristic of an ideal network lies in accurate and complete data delivery at the base station. Although the delays due to various factors concerned with routing the data packets from source to destination cannot be over cited, apart from it the congestion ,attacks and packet drops are always a matter of concern which all sum up together and do not ensure the correct and complete transmission of data from one end of the network to the other. Therefore the protocols being used as well as the routing techniques being used for data transmission should be thoroughly analyzed and improved upon. There are various kinds of routing in wireless sensor networks viz flat, hierarchical and location based. Various hierarchical protocols which deal with increasing the energy efficiency of WSN use the hierarchical routing in which lower level nodes sense the proximity of the target whereas the higher level nodes perform the task of sending information sent by the lower level nodes to the base station. To tackle the problem of energy efficiency of the wireless sensor networks many protocols have been developed over the years starting with LEACH(Low Energy Adaptive Clustering Hierarchy) Protocol [1] followed by HEED[2], A-LEACH[4],C-LEACH[5],M-LEACH[6] etc. The protocols like HEED, multihop LEACH, C LEACH. The second section discusses the related work, third section discussed the proposed technique, fourth section tells the result analysis and discussion finally the fifth and sixth sections describe the conclusion and future scope of the proposed technique.

II RELATED WORK

LEACH[1] is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. In LEACH, the nodes organize themselves into local clusters, with one node acting as the local base station or *cluster-head*. If the cluster heads were chosen a priori and fixed throughout the

system lifetime, as in conventional clustering algorithms, it is easy to see that the unlucky sensors chosen to be cluster-heads would die quickly, ending the useful lifetime of all nodes belonging to those clusters. Thus LEACH includes randomized rotation of the high-energy cluster-head position such that it rotates among the various sensors in order to not drain the battery of a single sensor. In addition, LEACH performs local data fusion to “compress” the amount of data being sent from the clusters to the base station, further reducing energy dissipation and enhancing system lifetime. Sensors elect themselves to be local cluster-heads at any given time with a certain probability. These cluster head nodes broadcast their status to the other sensors in the network. Each sensor node determines to which cluster it wants to belong by choosing the cluster-head that requires the minimum communication energy. Once all the nodes are organized into clusters, each cluster-head creates a schedule for the nodes in its cluster. This allows the radio components of each non-cluster-head node to be turned off at all times except during its transmit time, thus minimizing the energy dissipated in the individual sensors. Once the cluster-head has all the data from the nodes in its cluster, the cluster-head node aggregates the data and then transmits the compressed data to the base station

$$T(n) = \begin{cases} \frac{p}{1-p*(r \bmod \frac{1}{p})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (1) [1]$$

Where p is the desired percentage of cluster heads, r = the current round, and G is the set of nodes that have not been cluster heads in the last 1/p rounds. Since the base station is far away in the scenario we are examining, this is a high energy transmission. However, since there are only a few cluster-heads, this only affects a small number of nodes.one section of the environment that is not being “sensed” as nodes die, as occurs in the other protocols.

With the passage of time the need of multihop routing was felt which was supposed to increase the network lifetime as compared to the single hop routing protocols. The basic idea was that more would be the number of hops on which the data would be carried over before it reaches the base station, the more would be the extension of the time for which the networks would be active and functional[6]. Further, the caution is also to be kept while selecting the number of cluster heads nodes in the network as compared to the other sensor nodes in the cluster. The ideal value is 5 % for every 100 nodes in a network at a given time[4]. The other important point to be considered that the functions of data aggregation and calculation of the minimum distances from cluster heads to the base station should be divided between the various nodes other than the cluster heads in the higher levels of the protocol in the network like the helper nodes or gateway nodes so that cluster head nodes consume less energy as compared to the normal conditions for data transmission and thus are able to survive the network for longer duration of time especially in multihop routing so that the intended purpose is achieved.[5]

The concept of the multihop routing was discussed and implemented in multihop LEACH protocol[7]. Then another multihop routing protocol was proposed which gave the concept of introduction of gateway nodes in the network at the next level to the cluster head nodes[8]. The total number of the gateway nodes was about 10% of the total number of sensor nodes in the network. These would act as intermediaries for the transmission of data from the cluster heads to the base station. They followed a constraint that no two gateway nodes would transfer data to the gateway at the same time, rather the gateway nodes would provide them certain set time slots during which they would transmit data to them. At the given instant of time in the network if one gateway node is not free for transmission of data to the cluster head node, it would not waste time waiting for its turn, rather it would check the availability of other gateway nodes, which so ever is free, it would select it and transfer the data to it for transmission to the base station. Thus with increase of one more hop in the network, there is considerable extension in the network lifetime as compared to the single hop routing protocol.[9] Yet another protocol named Assisted LEACH[4] focuses on network lifetime goes down when both data aggregation and routing are carried out by Cluster Heads alone which can be eradicated by usage of Helper Nodes for Routing and Cluster Heads for Data Aggregation. It reduced the overhead for route formulation to base station by electing next hop at each Helper Node using the Received Signal Strength values of beacon signal from base station already available at helper nodes during Helper Node Selection phase. The concept of Helper Nodes in Assisted LEACH (A-LEACH) protocol has improved the lifetime of the network by distributing the minimized energy dissipation throughout the nodes.

A.UNDERSTANDING EFFECT OF ENERGY CONSUMPTION ON NETWORK

Mobility is also useful for reducing energy consumption. Packets coming from sensor nodes traverse the network towards the sink by following a multi-hop path. When the sink is static, a few paths can be more loaded than others, depending on the network topology and packet generation rates at sources. Generally, nodes closer to the sink also have to relay more packets so that they are subject to premature energy depletion, even when techniques for energy conservation are applied. On the other hand, the traffic flow can be altered if a designated mobile device makes itself responsible for data collection (mobile data collector). Ordinary nodes wait for the passage of the mobile device and route messages towards it, so that the communication with mobile data collector takes place in proximity (directly or at most with a limited multi-hop traversal). As a consequence, ordinary nodes can save energy thanks to reduced link errors, contention overhead and forwarding. In addition, the mobile device can visit the network in order to spread more uniformly the energy consumption due to data communication.[12] It is seen that in multi hop transmission consumes less energy than single hop. In large environmental setup sensor nodes are distributed pervasively, begin at same energy storage and

create clusters. Some of the clusters utilize more energy dissipation due to the far away from the base station and rest of the clusters operates at less energy consumption. Therefore, after the some successful rounds there will be a significant variation in nodes energy consumption. Finally, the network performance will be turn down because the distribution of the live and dead nodes within the network. Furthermore, during the setup phase, nodes short messages are collide to each other due to the nodes communication ranges are to each other and uses same frequency band. The network performance will be degrading partially; some of the nodes have not maintained the cluster membership and lost the network connectivity [13].

Cluster heads operate as a backbone of the network, multi hop routing strategy implies to reduce the energy consumption between the sensor nodes. period. Time Division Multiple Access scheduling to avoid collisions and reduce energy consumption between data messages in the cluster and enables each member of the radio equipment off when not in its time slot. During the time of each frame all member sensor nodes forward the data to cluster head, then cluster head combined and discard the unnecessary data and finally send the compact data to base station.[13] The energy expenditure of the sensor nodes occurs during the wireless communication, the environment sensing and the data processing. Therefore, most of the routing protocols in WSNs aim mainly at the attainment of power conservation. Most of the protocols use clusters in order to provide energy efficiency and to extend the network lifetime. Each cluster first elects a node as the cluster head (CH), and then, the nodes in every cluster send their data to their own cluster head. The cluster head sends its data to the base station. This data transfer can be performed in two alternative ways. Either directly, in the case in which the cluster head is located close to the base station, or via intermediate cluster heads. Moreover, in order to achieve balanced energy consumption and extend the network's lifetime, the election of the cluster heads should be performed in turns. In multi-hop, relay techniques being used which transmit data packets from the source node toward the direction of the sink. Relay techniques are used nodes as a temporary medium to transmit the packet from one node to the others[14].

The nodes can be called as an intermediate node since the nodes located between the sources and destination. Although multi-hop can improve communication between source and sinks in wireless sensor networks, the guarantee of multi-hop routes existence is not permanent or that the route particular paths exist for a short period of time.[14]

While multi-hop can solve the problem in large communication area, it has the capacity to improve energy efficiency in sensor nodes because multi-hop techniques requires transmission on neighboring nodes which are very close with each other thus decreasing the transmitter functionality. Routing in wireless sensor network has always been a problematic issue of concern mainly due to several factors ranging from unfriendly deployment conditions, network topology that change repeatedly, network failures, resource constraints at every sensor node to designing of routing protocol issues. Therefore, the

implementation of routing protocols is affected by several underlying features which must be taken into consideration before any attempt at designed routing are implemented, because these factors might prevent the successful design and implementation of routing protocol if these challenges are overlooked. The main goal of the routing protocols is efficient delivery of information between sensor nodes and the sink. Thus, energy consumption is a major concern in the design of routing protocol in WSNs. Due to the limited energy resources of sensor nodes, data need to be delivered in the most energy efficient approach without compromising the accuracy of the information content. Hence, many conventional routing metrics such as the shortest path algorithm may not be appropriate. Instead, the reasons for energy consumption should be carefully investigated, and new novel energy-efficient routing metrics developed for WSNs. The major reasons of energy consumption for routing in WSNs can be classified as Neighborhood discovery and Communication vs. Computation.[15]

Neighborhood discovery: Many routing protocols involves every node in order to exchange information between its neighbors. The information to be exchanged can differ according to the routing methods. While most geographical routing protocols involve knowledge of the locations of the neighbor nodes, a data-centric protocol may require the information content of the observed values of each sensor in its surrounding. In each case, nodes consume energy in exchanging this information during the wireless medium, which increases the overhead of the protocol. In order to improve the energy efficiency of the routing protocols, local information exchange should be minimized without hindering the routing accuracy[15].

Communication vs. Computation: It is well known that computation is greatly cheaper than communication in terms of energy consumption. Moreover, in WSNs, the goal is to deliver information instead of individual packets. Consequently, in addition to the conventional packet switching techniques, computation should also be integrated with routing to improve energy consumption. An example, data from multiple nodes can be aggregated into a single packet to decrease the traffic capacity without hindering the information content. Similarly, computation at each relay node can be used to suppress redundant routing information. For most networks, routing of incoming packets is normally concentrated in the network layer. In multi-hop networks the source node does not communicate directly to the sink, sensor nodes does the relaying of packets, so the protocols features a routing table which enables the routing algorithm to assist in the creation and maintenance of packet source and destination. [15]

III PROPOSED SCHEME

The proposed scheme[3] can be understood as under:-

A. Algorithm

The main goal of the approach is to extend network lifetime of the network[3]. For this reason, cluster head selection is mainly based on the residual energy of each node. The highest energy node that is if the remaining battery power is high then that node will become CH and

the least mobility node will become a CH. Distance of a node from the cluster centroid. The BS calculates the distance of each node to its cluster centroid. The lesser distance node from the BS to itself will have the higher probability to become a CH. The network initialization phase starts after the sensor nodes are randomly distributed in the application area. The base station broadcasts a “HELLO” message to all the nodes in the network to ensure that the network is alive. The algorithm starts with randomly selects a starting node that has not been visited and it retrieves all neighbor nodes which is density reachable from starting node with respect to Eps and MinPts. Here Eps is a radius of the cluster and MinPts is a minimum nodes required inside the cluster. If the number of neighbors is greater than or equal to MinPts then the cluster is formed as. Let the distance between two sets of nodes S1 and S2 be defined as $dist(S1, S2) = \min \{dist(p,q) \mid p \in S1, q \in S2\}$ and further the nodes with the highest energy are selected as cluster heads by the sensor nodes to which “ADVERTISEMENT” message is broadcasted by the CH and all the sensor nodes which join the cluster reply back with “ACK” message. The next phase deals with the selection of the cluster heads for each cluster. After the clusters are formed, the Base station should decide whether or not the node becomes a cluster head for the current round. To find that, the value of energy are computed for all the nodes in the network for each round. The node which has highest residual energy is elected the cluster head for the specific round.

Once the clusters are created and the CH issues a TDMA schedule to all the other sensor nodes in the clusters during which they need to transmit data to their Cluster heads. Base Station constantly observes the residual energy and Mobility of the existing CH. If it is below the threshold value then it select another CH based on same conditions, described earlier. Finally the CH should be checked out the routing path. If the routing path residual energy goes below the threshold or any node fails, BS selects another path and sends the routing path to the respective CH. So, the base station calculated the distance of all nodes in the network to itself using RSSI value[18] which is calculated with the help of two ray ground model

$$P_r(d) = \frac{P_t * G_t * G_r * h_t^2 * h_r^2}{d^4 L} \tag{4} [11]$$

where

P_r : Power received at distance d

P_t : Transmitted signal power

G_t : Transmitter gain (1.0 for all antennas)

G_r : Receiver gain (1.0 for all antennas)

d: Distance from the transmitter

L: Path loss (1.0 for all antennas)

h_t : Transmitter antenna height (1.5 m for all antennas)

h_r : Receiver antenna height (1.5 m for all antennas)

The data aggregated by all the cluster heads are sent to the helper nodes. The helper nodes are those which have second highest energy left in them at the end of each round. Sometimes there might be a situation when there is no such helper node left inside the cluster as it too has been drained

out of its energy so in that case the cluster head would search for some other available nearby helper node in some other cluster to which data can be transmitted. The cluster heads enter into sleep mode once they transmit data to the helper nodes so that their energies are saved. At a given time, all the cluster head nodes send data to the helper nodes using multihop routing. Further the helper nodes are informed of the shortest path calculated by the base station along which the data is transmitted again by multihop routing[3]. Thus this protocol would enhance the performance as well as improve the lifetime of wireless sensor network.

B. Radio Energy Dissipation Model

For the proposed protocol, the first order radio model is used for energy dissipation in communication [10], where radio dissipates $E_{elec} = 50$ nano Joule / bit to drive the transmitter and the transmit- amplifier dissipates $\epsilon_{elec} = 100$ pico Joule/ bit/m². To save energy, when required the radio can be turned on or off. Also the radio spends the minimum energy required to reach the destination. The energy consumed for data transmission of k bits packet is calculated from the Eq. (1).

$$E_{TX}(k,d) = E_{elec} * k + \epsilon_{elec} * k * d^2 \quad (2) \quad [10]$$

and to receive this message, the radio expends energy is shown in Eq. (2):

$$E_{RX}(k) = E_{RX-elec}(k) \quad (3) \quad [10]$$

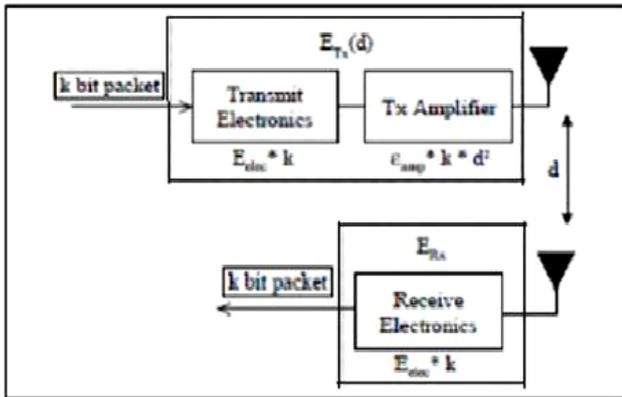


Fig 3 : Radio Dissipation Model [10]

IV RESULT ANALYSIS AND DISCUSSION

The simulation scenario consists of 50 sensor nodes deployed in the network field of size 1300m*1000 m in the wireless sensor network. All the simulations have been performed using NS2. The results have been obtained at the end of seven rounds of the network at simulation time = 30 sec for both the protocols. The graphs show two lines one in blue color and other in pink color .The blue line shows the results of the Assisted LEACH protocol and the pink line shows results of the proposed multihop LEACH protocol. The main objective of simulation is to analyze the effect on performance on the two multihop routing protocols by varying initial energy.

TABLE 1

SIMULATION PARAMETERS	
Simulator :	Ns-2.35
Simulation time :	30 sec
Channel Type:	Wireless
No of nodes:	50
Topology:	1300m *1000m
Radio Propagation model:	Two way ground
Communication Model :	Bi direction
Transmission Range:	250m
Interface Queue Type:	Queue/Drop Tail/Pri Queue
Initial energy:	100 Joules
Antenna Type:	Omni Antenna
Traffic Type:	CBR
Packet Size:	512 bytes

A. Performance Metrics

The performance analysis of the proposed protocol is done by comparing its results of Assisted LEACH Protocol which has been considered as the base protocol for the development of the proposed scheme by using some of the performance metrics such as:

1)Throughput[3]: It is the measure of the number of bits of data packets that are transmitted from source to destination in given time. It is always less than 1. The formula of measuring throughput is

$$\frac{\text{Number of bytes received}}{\text{Time in milliseconds}} \quad (5) \quad [3]$$

Generally it is measured in Kb/sec or Bytes/sec. For the protocol aiming to enhance the throughput of the network , it is must that the packet drop rate, jitters , routing overheads and congestion or packet loss should be as less as possible otherwise lower value of throughput would decrease the data packets delivery from the source to the destination.

2)Average Energy Consumption (Ea) [3]

The average energy consumption is calculated across the entire topology. It measures the average difference between the initial level of energy and the final level of energy that is left in each node.

Let E_i = the initial energy level of a node, E_f = the final energy level of a node and N = number of nodes in the simulation. Then

$$E_a = \sum_{k=1}^n (E_{ik} - E_{fk}) / N \quad (6) \quad [3]$$

This metric is an important because the energy level of the network uses is proportional to the network’s lifetime. The lower the energy consumption the longer is the network’s lifespan. Thus the ideal value for average energy consumed by the protocol should be as less as possible otherwise if the protocol would consume more energy after every round then it would become difficult to increase the lifetime of the network . The exact formula for calculation of average energy is inbuilt in NS2.

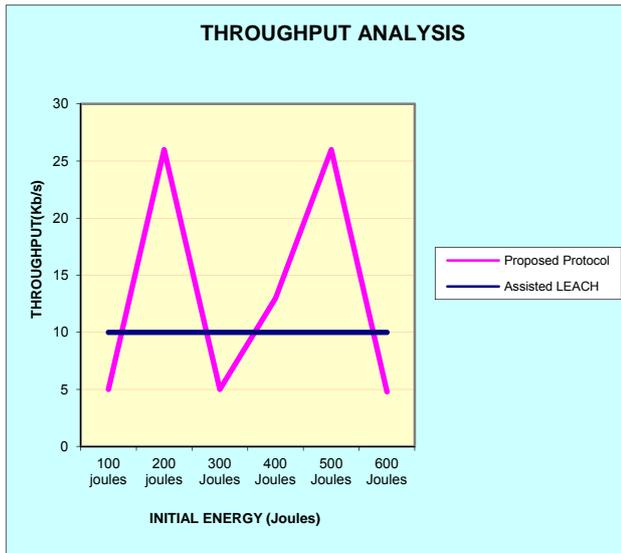


Fig 4 : Graph showing comparison of two protocols based on throughput.

The graph clearly shows that by varying the initial energy from 100 Joules to 600 Joules, the Assisted LEACH protocol shows no change in throughput over seven rounds of simulation whereas for the proposed protocol the throughput shows great variation right from the beginning till the further rounds. The value of throughput is highest at 200 and 500 Joules of energy and it drops and rises alternately as the value of initial energy keeps on increasing through to further rounds of network simulation.

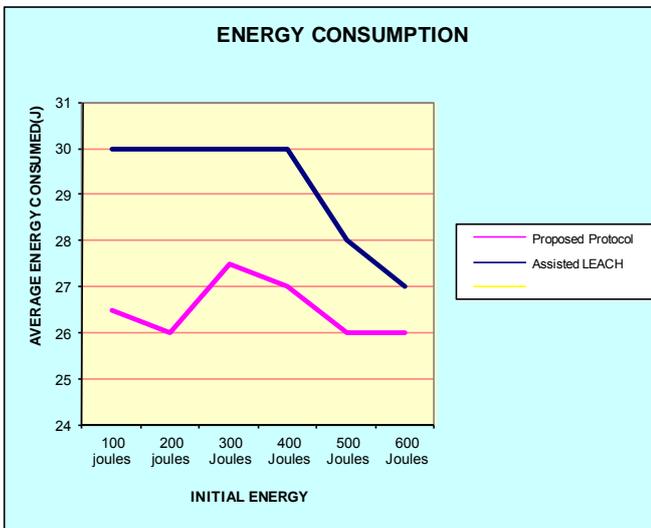


Fig 5: Graph showing comparison of two protocols based on average energy.

The graph clearly shows that by varying the initial energy from 100 Joules to 600 Joules, the Assisted LEACH protocol shows a stable consumption of energy upto 400 Joules and then it becomes lower down for 500 Joules onwards whereas the proposed multihop protocol shows comparatively less consumption of energy thus it helps in extending the network lifetime for a longer period of time at the end of seven rounds of simulation. The proposed protocol shows quite a variation for the initial values of initial energy and then it drops down steeply from 400 to 500 Joules and then stabilizes from there onwards.

TABLE 2
SUMMARY OF RESULTS

Initial Energy	Assisted LEACH		Proposed Scheme	
	Throughput	Average Energy	Throughput	Average Energy
100 Joules	10 Kb/s	30 Joules	5 Kb/s	26.5 J
200 Joules	10 Kb/s	30 Joules	26 Kb/s	26 J
300 Joules	10 Kb/s	30 Joules	5 Kb/s	27.5 J
400 Joules	10 Kb/s	30 Joules	13 Kb/s	27 J
500 Joules	10 Kb/s	28 Joules	26 Kb/s	26 J
600 Joules	10 Kb/s	27 Joules	4.8 Kb/s	26 J

V. CONCLUSION

The above results provide an insight to the fact that by varying the initial energy while transmission of data over the network and analyzing its impact on the various performance metrics the inference thus drawn is that due to difference in main technique of both the multihop routing protocols the results show that the proposed multihop routing protocol shows great rise and drops in the value of throughput but the Assisted LEACH protocol maintains a constant value. As regards the energy consumption of both the protocols is concerned, the Proposed multihop routing protocol consumes much less energy for data transmission as compared to Assisted LEACH Protocol. Therefore the proposed scheme would definitely extend the network lifetime as compared to the other protocol.

VI. FUTURE SCOPE

In future many other techniques should be developed which should focus on improving upon the energy conservation strategies so that the lifetime as well as the performance of the wireless sensor networks can be improved. The routing as well as data aggregation and transmission methods need to be changed as presently all methods expend much of the energy while sensing, aggregating the data till they route it to the base station. The adaptability of the protocols can be checked out and they even can be made more flexible to all kinds of applications as well as environments from time to time.

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